PB-217 980

REPORT ON POLLUTION OF THE MERRIMACK RIVER AND CERTAIN TRIBUTARIES. PART VI. PEMIGEWASSET RIVER

Federal Water Pollution Control Administration
Lawrence, Massachusetts

August 1966

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REPORT ON

POLLUTION OF THE MERRIMACK RIVER

AND CERTAIN TRIBUTARIES

PART VI - PEMIGEWASSET RIVER

U. S. Department of the Interior
Federal Water Pollution Control Administration
Northeast Region
Merrimack River Project
Lawrence, Massachusetts

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TABLE OF CONTENTS:

	PAGE NO.
INTRODUCTION	1
THE AREA	3
SOURCES OF POLLUTION	4
GENERAL	4
BACTERIA	6
SUSPENDED SOLIDS	9
BIOCHEMICAL OXYGEN DEMAND	9
SULFITE WASTE LIQUOR	10
WATER USES	11
MUNICIPAL USE	11
INDUSTRIAL USE	11
RECREATION	12
EFFECTS OF POLLUTION ON WATER QUALITY AND USES	15
BACTERIAL POLLUTION	15
SUSPENDED SOLIDS	18
DISSOLVED OXYGEN	20
SULFITE WASTE LIQUOR	22
FUTURE WATER QUALITY	26
SUMMARY AND CONCLUSIONS	29
APPENDIX	33

LIST OF FIGURES

FIGURE NO.		FOLLOWS PAGE NO.
1	Pemigewasset and Merrimack Rivers	Appendix A-3
2	Coliform Bacteria Population Equivalents	8
3	Suspended Solids Population Equivalents	10
4	Biochemical Oxygen Demand Loads	10
5	Contribution of Sulfite Waste Liquor . .	10
6	Dissolved Oxygen in the Pemigewasset River	22
7	Sources of Sulfite Waste Liquor to Pemigewasset-Merrimack Rivers Above Lawrence, Massachusetts	22
8	True Color vs. Sulfite Waste Liquor as Found in Merrimack River Basin . .	24
9	Minimum Alum Required to Reduce Color to 15 ppm or Less	26

LIST OF TABLES

TABLE NO.		PAGE NO.
1	Estimated Characteristics of Sewage and Industrial Wastes Discharged to Pemigewasset River and Tributaries Within Study Area	7
2	New Hampshire Water Use Classification and Quality Standards	16

INTRODUCTION

In accordance with the written request to the Secretary of Health, Education, and Welfare from the then Governor Endicott Peabody of Massachusetts, dated February 12, 1963, and on the basis of reports, surveys, or studies, the Secretary of Health, Education, and Welfare, on September 23, 1963, called a conference under the provisions of the Federal Water Pollution Control Act, as amended (33 USC 466 et seq.), in the matter of pollution of the interstate waters of the Merrimack and Nashua Rivers and their tributaries (Massachusetts-New Hampshire) and the intrastate portions of those waters within the state of Massachusetts. Interstate pollution originating in the Pemigewasset River Basin was included in this conference. The conference was held February 11, 1964, in Faneuil Hall, Boston, Massachusetts.

Subsequent to the conference, the Secretary of Health, Education, and Welfare recommended appropriate pollution abatement action. For pollution originating in New Hampshire, he recommended that the New Hampshire Water Pollution Commission take appropriate action under its water pollution control program, and state and local law, to insure that a commensurate program with that proposed by Massachusetts be carried out. Essentially, this meant that, for Franconia Paper Corporation, Lincoln, New Hampshire, a definite time schedule for completion of final plans, financing, and construction was to be established no later than the end of 1965.

This report is based on data, reports and other materials furnished by the New Hampshire Water Pollution Commission, the Massachusetts Department of Public Health, and the New England Interstate Water Pollution Control Commission; data furnished by the cities of Lowell and Lawrence, Massachusetts; information furnished by other interested Federal agencies; information provided by citizens living in the Pemigewasset River Basin; official records of the U. S. Department of the Interior; and data obtained by the Merrimack River Project through field and laboratory studies. The cooperation of the numerous agencies and individuals is gratefully acknowledged.

THE AREA

The Pemigewasset River, which is situated entirely within New Hampshire, has its headwaters in the White Mountains. This river drains 1,021 square miles and flows in a generally southerly direction to Franklin, New Hampshire, some sixty-four miles downstream. The average slope is twenty-five feet per mile. The East Branch Pemigewasset River joins the North Branch about fifty-four miles above its mouth and has a drainage age of 115 square miles.

At Franklin, New Hampshire, the Winnipesaukee River joins the Pemigewasset River to form the Merrimack River, as shown in Figure 1 at the back of this report. The changing of the name of the river does not end the interstate waterway. Therefore, the Pemigewasset, being the major tributary, is a continuation of the Merrimack River. The Merrimack flows in a southerly direction from Franklin. After entering Massachusetts, it turns abruptly east for a distance of about forty-five miles, where it empties into the Atlantic Ocean at Newburyport, Massachusetts. The Merrimack River has a total length of 116 miles with a watershed area of 5,010 square miles, of which 3,800 square miles are in New Hampshire and 1,210 square miles are in Massachusetts.

The Pemigewasset River Basin includes prime recreation area with the result that there is a considerable tourist population during the summer and winter months. Waters of the Pemigewasset River would be available for many uses if the pollution of the river were abated.

SOURCES OF POLLUTION

GENERAL

Both sewage and industrial wastes contain a variety of obnoxious constituents which can damage water quality and restrict its use. Oxygen-demanding materials can limit or destroy fish, fish food organisms and other desirable aquatic life by removing dissolved oxygen from the river. Greasy substances can form objectionable surface scums, settleable solids can create sludge deposits, and suspended materials can make once attractive waters appear turbid. Materials causing a stream to be colored make it esthetically unpleasant and can make municipal and industrial water supplies more expensive to treat.

Industrial wastes may also contain objectionable chemicals and toxic substances that can kill aquatic life, taint fish flesh or promote slime growths in the receiving waters. Heat from industrial processes or steam-electric generating plants can magnify the adverse effects of other decomposing wastes and, if excessive, can injure or kill fish and aquatic life.

Sewage contains astronomical numbers of intestinal bacteria which were released in man's excretions. Some of these may be pathogens which can reinfect man with a variety of diseases.

The oxygen demand of sewage and industrial wastes, as measured by the 5-day biochemical oxygen demand test, indicates their

potential for reducing the dissolved oxygen content of the river waters. The coliform bacteria content of raw and treated sewage indicates the density of sewage-associated bacteria, which may include disease-producing organisms, discharged to the river. The oxygen-demanding loads are expressed as population equivalents (PE) of 5-day biochemical oxygen demand (BOD); the bacterial loads are expressed as bacterial population equivalents (BPE) of total coliform bacteria. Each PE or BPE unit represents the average amount of oxygen demand or coliform bacteria normally contained in sewage contributed by one person in one day. (One PE equals one-sixth pound per day of 5-day BOD, and one BPE equals about 250 billion coliform bacteria per day.)

Primary treatment plants, which consist essentially of settling tanks and sludge digesters, can remove most of the scum and settleable solids, about one-third of the oxygen-demanding material and approximately 50 per cent of the bacteria. Secondary plants consist of biological treatment units, such as trickling filters, activated sludge systems or oxidation lagoons. Such plants can remove about 90-95 per cent of the BOD, suspended solids and coliform bacteria. Chlorination facilities for disinfection of properly treated sewage plant effluents can destroy more than 99 per cent of the sewage bacteria. To accomplish these reductions, however, treatment facilities must be properly designed and skillfully operated.

Raw and partially treated sewage and industrial wastes are discharged along most of the length of the Pemigewasset River.

A summary of the waste discharged is presented in Table 1. The values are based primarily on studies by the New Hampshire Water Pollution Control Commission.

BACTERIA

Billions of bacteria, frequently including disease-causing organisms, are contained in the excreta of each person. If these bacteria are not drastically reduced by suitable treatment of the wastes, large numbers enter the streams receiving the wastes. Coliform bacteria, including those whose normal habitat is the intestinal tract of man and other warm-blooded animals, are normally used as indicators of recent bacterial pollution.

Only two of the seven jurisdictions responsible for the discharge of sewage in the study area have any type of treatment. Plymouth has a waste stabilization pond which serves only a small portion of the population. New Hampton also has a waste stabilization pond.

Plymouth, New Hampshire, with a discharge containing a bacterial population equivalent of 1,220 is responsible for 25.1 per cent of the total estimated bacterial pollution in the Pemigewasset River. Bristol contributes 24.6 per cent of the total while Lincoln, Ashland and North Woodstock contribute 20.5, 14.4 and 10.3 per cent, respectively. The data are illustrated in Figure 2.

TABLE 1

ESTIMATED CHARACTERISTICS OF SEWAGE AND INDUSTRIAL WASTES

DISCHARGED TO PEMIGEWASSET RIVER AND TRIBUTARIES WITHIN STUDY AREA

DISCHARGE	TYPE OF TREATMENT	POPULATION EQUIVALENTS DISCHARGED					
		BACTERIAL		SUSPENDED SOLIDS		OXYGEN DEMAND	
		NUMBER	% TOTAL	NUMBER	% TOTAL	NUMBER	% TOTAL
Franconia Paper Corp., Lincoln	None-except that bark is burned	----	----	200,000	69.57	400,000	94.52
Lincoln	None	1,000	20.5	1,000	0.35	1,000	0.24
North Woodstock	None	500	10.3	500	0.17	500	0.12
Campton	None	200	4.1	200	0.07	200	0.04
Plymouth	Partly untreated Partly oxidation pond	1,220	25.1	1,230	0.43	1,220	0.29
Ashland	None	700	14.4	700	0.24	700	0.17
Ashland Paper Mills, Ashland	None	----	----	78,000	27.13	12,000	2.84
L. W. Packard Co., Ashland	Flock recovery	----	----	4,100	1.43	5,800	1.37
New Hampton	Oxidation pond	50	1.0	70	0.02	50	0.01

TABLE 1 (Continued)

DISCHARGE	TYPE OF TREATMENT	POPULATION EQUIVALENTS DISCHARGED					
		BACTERIAL		SUSPENDED SOLIDS		OXYGEN DEMAND	
		NUMBER	% TOTAL	NUMBER	% TOTAL	NUMBER	% TOTAL
Bristol	None	1,200	24.6	1,200	0.42	1,200	0.28
Louis Verza Leather, Inc., Franklin	Sedimentation	----	----	500	0.17	500	0.12
TOTAL		4,870	100.00	287,500	100.00	423,170	100.00

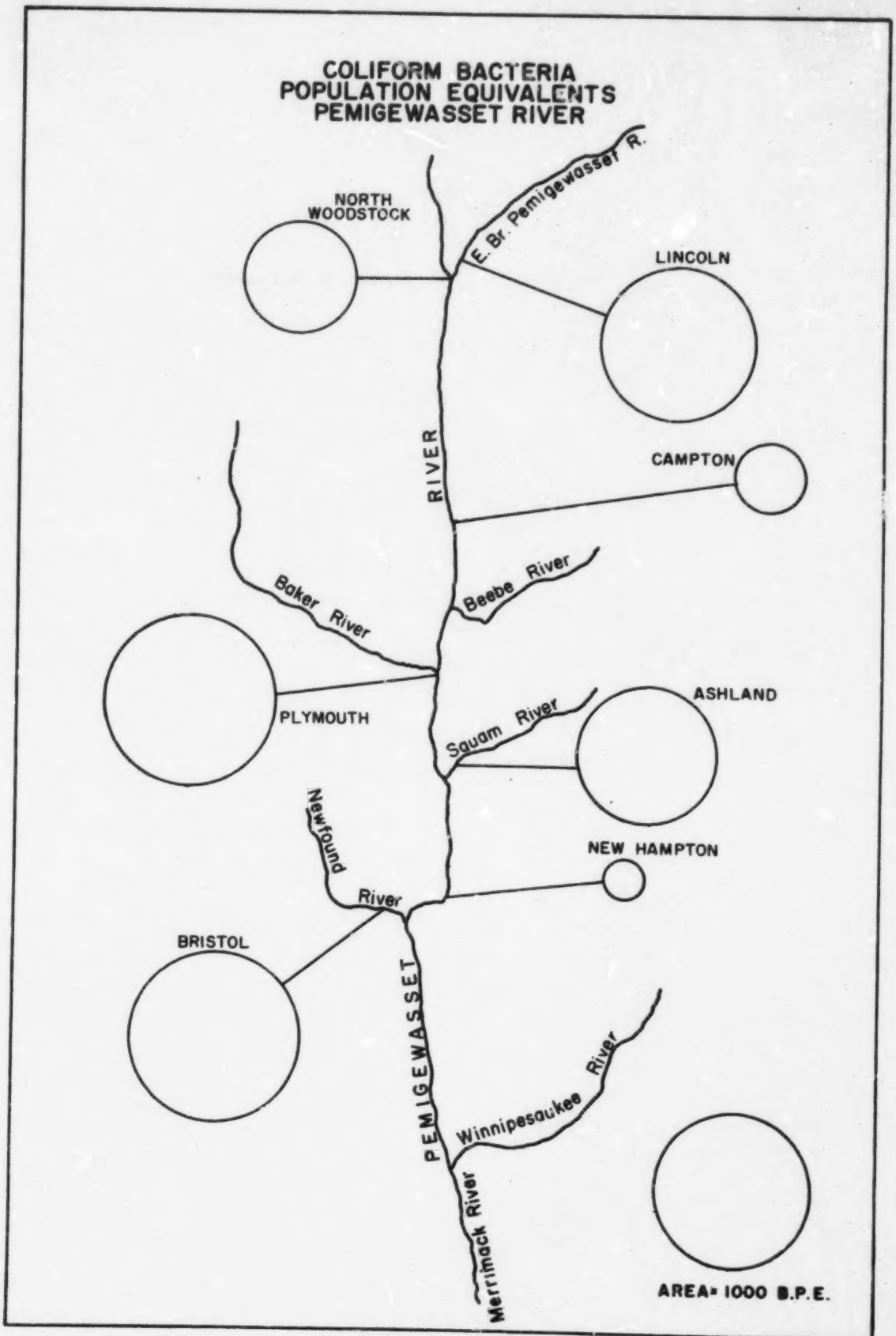

COLIFORM BACTERIA
POPULATION EQUIVALENTS
PEMIGEWASSET RIVER
NORTH WOODSTOCK
E. Br. Pemigewasset R.
LINCOLN
RIVER
CAMPTON
Baker River
Beebe River
PLYMOUTH
Squam River
ASHLAND
Newfound River
NEW HAMPTON
BRISTOL
PEMIGEWASSET
Winnipesaukee River
Merrimack River
AREA= 1000 B.P.E.

FIGURE 2

SUSPENDED SOLIDS

The over-all suspended solids discharged to the Pemigewasset River watershed are equivalent to those in the raw sewage of 287,500 persons. Over 98 per cent of all the suspended solids discharged emanate from industrial plants. The largest source of suspended solids is the Franconia Paper Corporation of Lincoln, New Hampshire, where 200,000 suspended solids population equivalents, approximately 70 per cent of the total, originate. Ashland Paper Mills in Ashland discharge approximately 27 per cent of the total suspended solids. Figure 3 indicates the relative amount of suspended solids discharged to the Pemigewasset River system from each source.

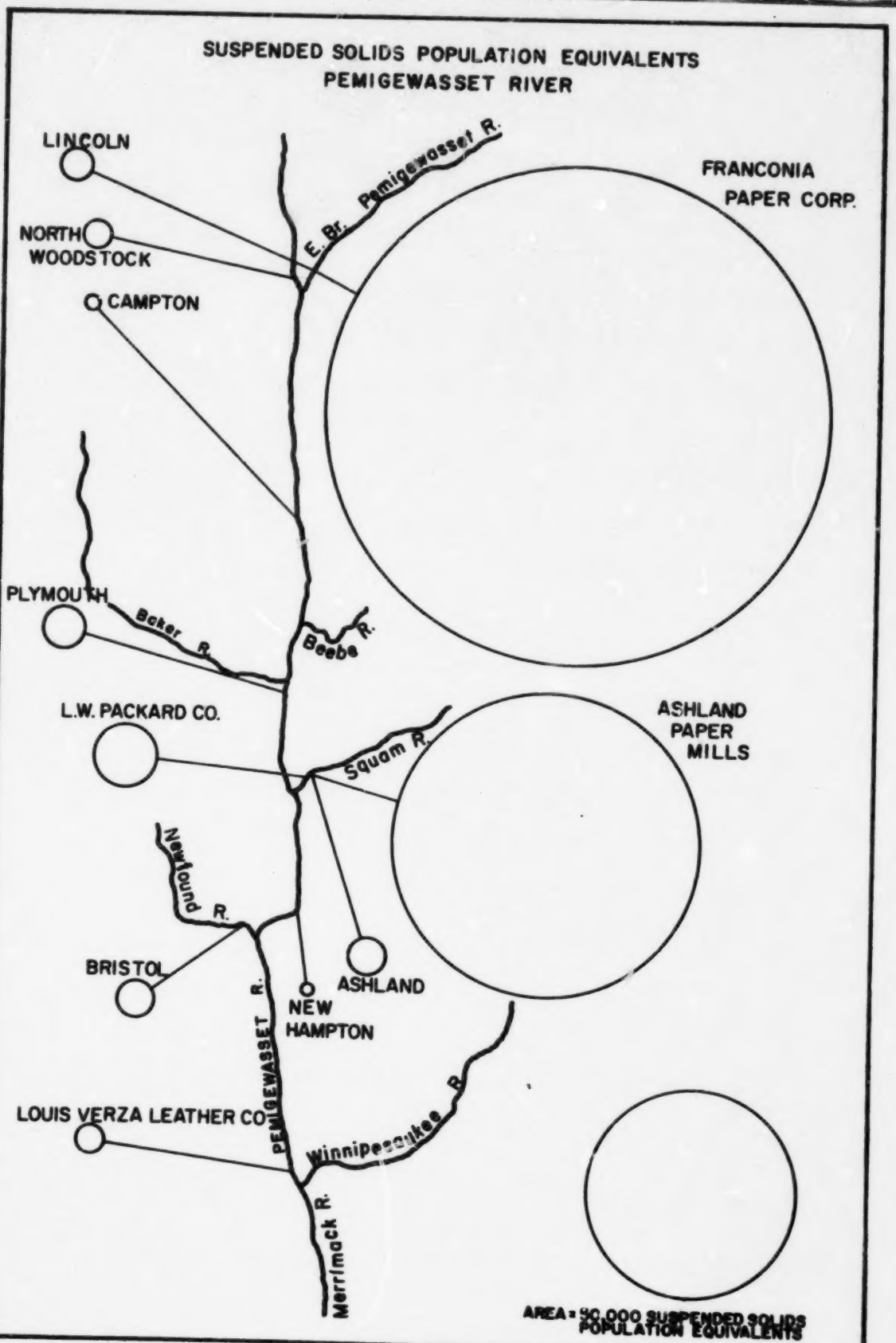
BIOCHEMICAL OXYGEN DEMAND

Sewage and industrial wastes presently discharged to the Pemigewasset River have an estimated biochemical oxygen demand (BOD) population equivalent of 423,170. Industrial discharges contribute approximately 99 per cent of the total. The wastes from Franconia Paper Corporation of Lincoln, New Hampshire, contain a biochemical oxygen demand equivalent to the raw sewage from approximately 400,000 persons. This discharge accounts for 94.5 per cent of the total BOD discharged in the Basin, while Ashland Paper Mills in Ashland contributes approximately 2.8 per cent, and L. W. Packard Company in Ashland discharges approximately 1.4 per cent of the total oxygen demanding material. The BOD loadings are shown in Figure 4.

SULFITE WASTE LIQUOR

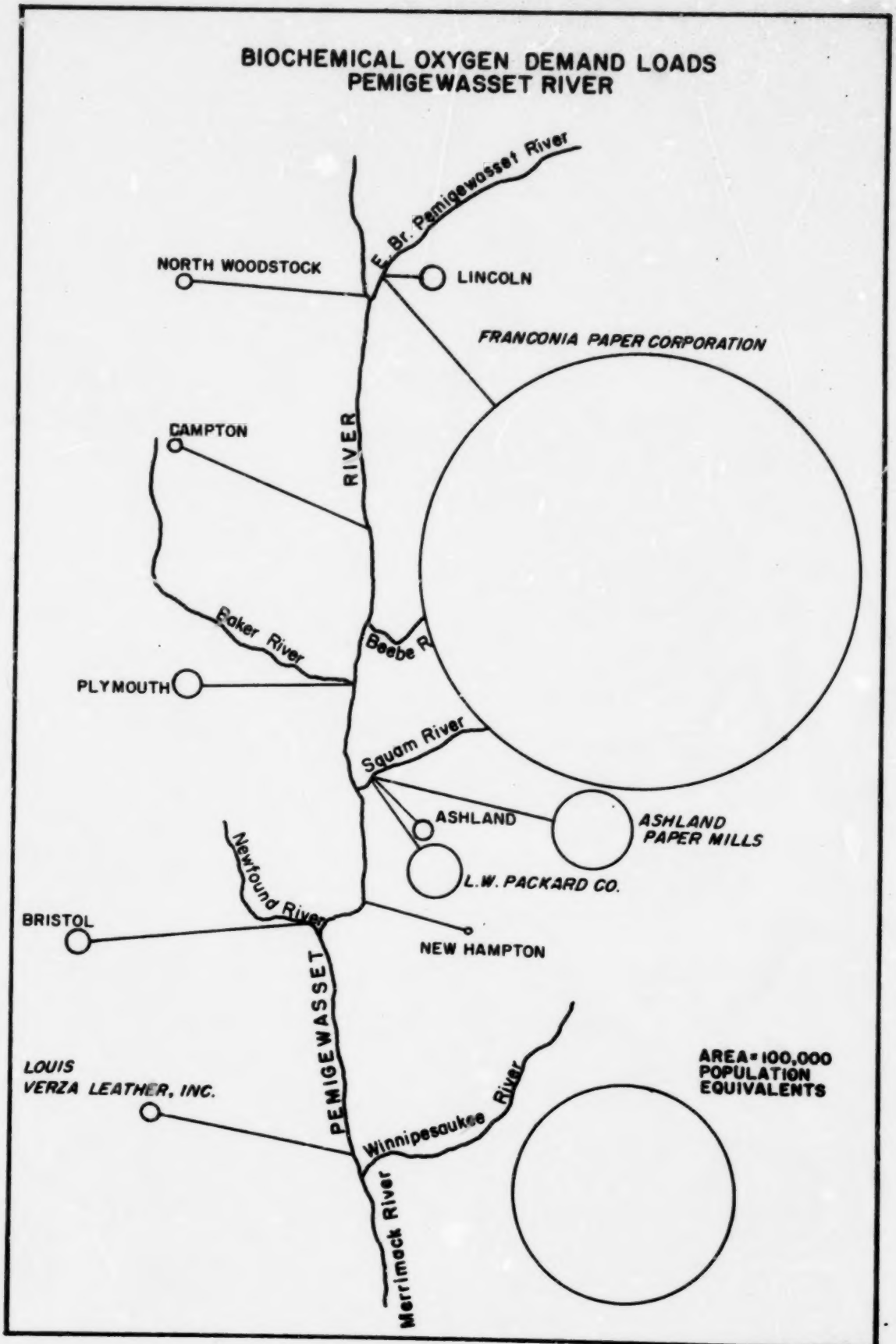
Sulphite waste liquor (SWL) arises from the delignification of wood with a bisulfite-sulfurous acid solution and contains about 10 per cent of solutes which are non-volatile at the cooking temperature. These solutes consist of about 65 per cent lignin sulfonates and 25 per cent sugars. A standardized method, called the Pearl-Benson method, is used to estimate sulfite waste liquor concentration in waters.

During 1965 the Merrimack River Project examined the sulfite waste liquor concentration in every significant tributary of the Pemigewasset River and, also, the amount of this material from the Franconia Paper Corporation at Lincoln, New Hampshire. Each tributary contained some "lignin-like" materials, however slight. Of the total amount of sulfite waste liquor reaching the mouth of the Pemigewasset River at Franklin, New Hampshire, it is conservatively estimated that 99.2 per cent originates with the Franconia Paper Corporation. The remaining 0.8 per cent comes from all the Pemigewasset River tributaries combined. The relative amount of sulfite waste liquor from each source is shown in Figure 5.


SUSPENDED SOLIDS POPULATION EQUIVALENTS
PEMIGEWASSET RIVER
LINCOLN
NORTH WOODSTOCK
CAMPTON
E. Br. Pemigewasset R.
FRANCONIA PAPER CORP.
PLYMOUTH
Baker R.
Beebe R.
L.W. PACKARD CO.
Squam R.
ASHLAND PAPER MILLS
Newfound R.
BRISTOL
ASHLAND
NEW HAMPTON
PEMIGEWASSET R.
LOUIS VERZA LEATHER CO.
Winnipesaukee R.
Merrimack R.
AREA = 30,000 SUSPENDED SOLIDS POPULATION EQUIVALENTS

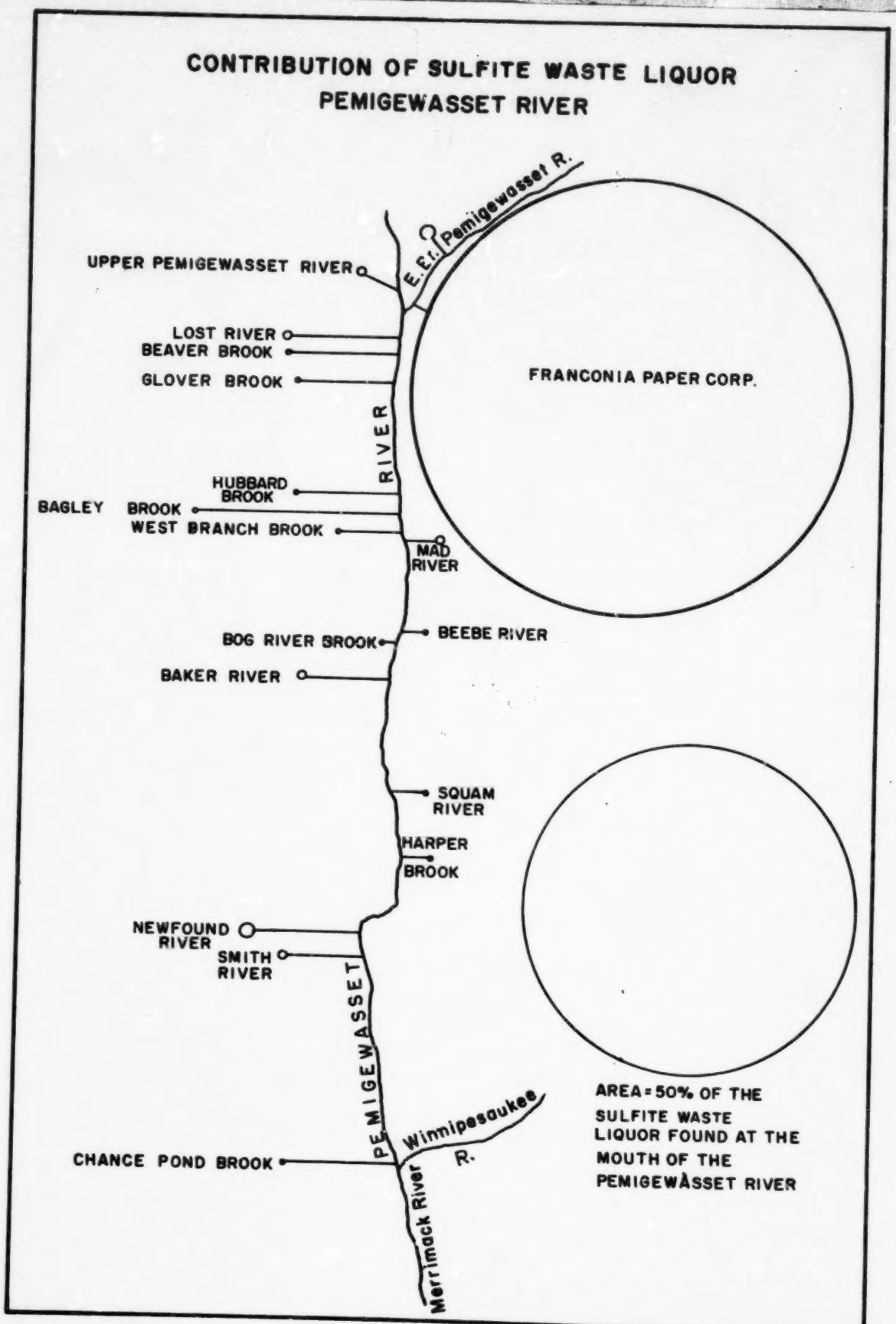
10 4

FIGURE 3


BIOCHEMICAL OXYGEN DEMAND LOADS
PEMIGEWASSET RIVER
E. Br. Pemigewasset River
NORTH WOODSTOCK
LINCOLN
FRANCONIA PAPER CORPORATION
CAMPTON
RIVER
Baker River
Beebe R
PLYMOUTH
Squam River
ASHLAND
ASHLAND PAPER MILLS
L.W. PACKARD CO.
Newfound River
BRISTOL
NEW HAMPTON
PEMIGEWASSET
LOUIS VERZA LEATHER, INC.
Winnipesaukee River
Merrimack River
AREA = 100,000 POPULATION EQUIVALENTS

10C

FIGURE 4


CONTRIBUTION OF SULFITE WASTE LIQUOR
PEMIGEWASSET RIVER
E. Br. Pemigewasset R.
UPPER PEMIGEWASSET RIVER
LOST RIVER
BEAVER BROOK
GLOVER BROOK
FRANCONIA PAPER CORP.
RIVER
HUBBARD BROOK
BAGLEY BROOK
WEST BRANCH BROOK
MAD RIVER
BOG RIVER BROOK
BEEBE RIVER
BAKER RIVER
SQUAM RIVER
HARPER BROOK
NEWFOUND RIVER
SMITH RIVER
PEMIGEWASSET
Winnipesaukee R.
CHANCE POND BROOK
Merrimack River
AREA = 50% OF THE SULFITE WASTE LIQUOR FOUND AT THE MOUTH OF THE PEMIGEWASSET RIVER

10 d

FIGURE 5

WATER USES

MUNICIPAL USE

Although there is no municipal water use of the Pemigewasset River at the present time, two communities withdraw water downstream of the Pemigewasset. Lawrence, Massachusetts, has been using the Merrimack River as a source of municipal water supply since 1893, with an estimated 90,000 persons in Lawrence and Methuen being served by the treated water. The principal source of water supply for the city of Lowell, Massachusetts, since January 1963, has been the Merrimack River. Approximately 65,000 persons are served by this treated water. Lowell's water intake is located 6.4 miles below the New Hampshire-Massachusetts state line

With the rapidly increasing populations in many of the cities and towns along the Merrimack River, additional municipalities may need to make use of this convenient source of water supply. Concord, Manchester and Nashua, New Hampshire, and Chelmsford, Tyngsboro, Andover, Tewksbury and West Newbury, Massachusetts, have already been mentioned as potential users of the Merrimack River.

INDUSTRIAL USE

There are four major industrial water users other than those which use the water only for generating electricity in the Pemigewasset River watershed. The Franconia Paper Corporation, Lincoln, New Hampshire,

dollars annually would be added to the economy of the Merrimack Basin. No doubt the benefits would be greater today because of the increased pressure for recreation. The total economic loss in the Merrimack River Basin due to pollution is estimated to be over thirty-seven million dollars a year.

Hiking, hunting, fishing, bathing, boating and sight-seeing are all important recreational uses enjoyed in the Pemigewasset River watershed. The White Mountain National Forest which is located north of Campton, New Hampshire, offers a variety of recreational activities. The U. S. Forest Service maintains numerous hiking trails, and much of the region away from the main river is semi-wilderness that provides big game hunting for deer and black bear.

Nearly all the tributaries to the Pemigewasset River are fished for trout. Salmon, until the 1800's, ascended the Pemigewasset River at least as far as Livermore Falls, Officials of the U. S. Fish and Wildlife Service have stated that if pollution in the Merrimack and Pemigewasset Rivers were eliminated, fish elevators could be built at the dams, and anadromous fish, including salmon, could be reintroduced in the rivers. Landlocked salmon ascend the Cockermouth and Fowler Rivers from Newfound Lake during the spawning season each year. The Pemigewasset River has trout in the upper reaches above Lincoln but none below since the severe pollution caused by Franconia Paper Corporation's pulp and paper wastes renders the stream unfit for fish life. The New Hampshire State Planning and Development Commission stated that

recreational property was a substantial portion of all property in the Pemigewasset River watershed and that the percentage of recreational property is increasing each year.

The completion of Interstate Highway 93 to Plymouth, New Hampshire, and the opening of the Kancamagus Highway in the White Mountains made the Pemigewasset River area more readily accessible from the metropolitan areas of Boston, New York and Montreal.

A great influx of people occurs each summer in the Pemigewasset River watershed. It is of interest to note that, in general, this summer increase of population takes place within a narrow band lying along the Pemigewasset River and on major lakes.

Local governments in the Pemigewasset River watershed derive approximately 50 per cent greater tax support than the state average from recreational property. This is due in part to the fact that non-residents of New Hampshire have bought, rebuilt or redecorated old farm houses for summer residences. Recreation and industry are the two top sources of total income in the Pemigewasset River watershed.

It is expected that the demand for recreational facilities of all types will increase in the future, with rivers and lakes being the nucleus of most of these facilities.

EFFECTS OF POLLUTION ON WATER QUALITY AND USES

Water quality of the Pemigewasset River has been studied frequently by the New Hampshire Water Pollution Commission between 1946 and the present time. In a staff report published November 1958, the Commission indicated that the Pemigewasset River was generally of Class D (Table 2) or below this condition from its confluence with the East Branch at Lincoln, New Hampshire, to the Public Service Company of New Hampshire's dam in Franklin, a distance of fifty-three miles.

During 1965 the Merrimack River Project made studies of the sulfite waste liquor in the Pemigewasset River Basin and downstream waters.

BACTERIAL POLLUTION

Municipal sewage contains enormous numbers of bacteria, among which there are frequently pathogenic bacteria that can cause gastrointestinal diseases such as typhoid fever, dysentery and diarrhea. The pathogenic organisms can cause illness to persons who swallow water containing them. Infectious hepatitus, a virus disease, can also be caused by ingesting sewage-polluted water; and eye, ear, nose, throat or skin infections may result from bodily contact with such waters. If the densities of pathogenic organisms are reduced by sewage treatment, dilution or by natural self-purification, the hazards of contracting disease are proportionately reduced.

TABLE 2

NEW HAMPSHIRE WATER USE CLASSIFICATION
AND QUALITY STANDARDS

	CLASS A	CLASS B		CLASS C	CLASS D
		B-1	B-2		
	Potentially acceptable for public water supply after disinfection. (Quality uniformly excellent.)	Acceptable for bathing and recreation, fish habitat and public water supply after adequate treatment. (High esthetic value.)	Acceptable for recreational boating, fish habitat, industrial and public water supplies after adequate treatment. (High esthetic value.)	Acceptable for recreational boating, fish habitat, and industrial water supply. (Third highest quality.)	Devoted to transportation of sewage or industrial waste without nuisance. (Lowest classification.)
Dissolved oxygen	Not less than 75% sat.	Not less than 75% sat.	Not less than 75% sat.	Not less than 5 ppm.	Present at all times.
Coliform bacteria MPN/100 ml.	Not more than 50	Not more than 240	Not more than 1,000.	Not specified	Not specified.
pH	5.0 - 8.5	5.0 - 8.5	5.0 - 8.5	5.0 - 8.5	Not specified.
Substances potentially toxic	None	Not in toxic concentrations or combinations.	Not in toxic concentrations or combinations.	Not in toxic concentrations or combinations.	Not in toxic concentrations or combinations.
Sludge deposits	None	Not in objectionable amounts.	Not in objectionable amounts.	Not in objectionable amounts.	Not in objectionable amounts.
Oil and grease	None	None	Not in objectionable amounts.	Not in objectionable amounts.	Not of unreasonable quantity or duration.
Color and turbidity	Not in objectionable amounts.	Not in objectionable amounts	Not in objectionable amounts.	Not in objectionable amounts.	Not of unreasonable quantity or duration.
Slick, odors and surface-floating solids	None	None	Not in objectionable amounts.	Not in objectionable amounts.	Not of unreasonable quantity or duration.

NOTE: The waters in each classification shall satisfy all provisions of all lower classifications.

Sewage also contains bacteria of the coliform group which can readily be detected even at low densities. These bacteria, although most are harmless themselves, are indicators of the probable presence of pathogenic bacteria and viruses. Coliform organisms are, therefore, used as a tool in evaluating bacterial pollution of streams and as a basis for water quality objectives for various water uses.

The coliform group is usually designated as total coliforms with test results expressed in terms of numbers per 100 milliliters (ml) of water. One hundred milliliters is a little less than one-half cup.

For sources of municipal water supplies, the New Hampshire limit is 1,000 coliform bacteria per 100 milliliters, provided the water treatment is adequate. The New Hampshire limit for bathing waters is 240 coliforms per 100 ml.

No total coliform standard of water quality has been adopted for the recreational uses of fishing and boating. Where such a limit has been adopted in other states, the commonly used value is 5,000 per 100 ml.

With the exception of the waste stabilization ponds treating sewage from New Hampton and a portion of the sewage from Plymouth, New Hampshire, there has been no reduction of sewage entering the Pemigewasset River since the 1958 report was published by the New Hampshire Water Pollution Commission. Therefore, the 1958 conditions should be indicative of conditions at the present time, but with a lower peak

coliform density below Plymouth.

About twenty-nine of the thirty-five miles of stream between North Woodstock and New Hampton are above 5,000 coliforms per 100 ml and are not suitable for recreational uses without adequate treatment of present sewage discharges.

SUSPENDED SOLIDS

Excessive suspended solids in a stream diminish the beauty of the water. When they flow through a slow-moving section of the stream, such as an impoundment, the particles tend to settle to the bottom to form sludge. The blanket of sludge on the bottom of the river covers the areas which otherwise would be used by fish in spawning and, thereby, reduce the fish population below its potential. In addition, the sludge-covered bottom is not a suitable habitat for insect larvae or other aquatic life which normally live on the bed of a clean stream and serve as food for the fish. If the sludge deposits exert an oxygen demand, the oxygen may be depleted, and gases with offensive odors may be given off. In many cases these gases contain hydrogen sulfide. The sulfide may react with points on buildings, boats and structures, and discolor the paint.

Frequently the gases from decomposition buoy up the sludge, which will then float on the stream surface causing unsightly conditions. Gas bubbles can be seen at many locations along the Pemigewasset River.

Ideally, a stream bottom should be free of pollutants that will adversely affect the composition of the bottom fauna, interfere with the spawning of fish or their eggs, or adversely affect the physical or chemical nature of the bottom. Sludge on the bottom of the Pemigewasset River causes all of these adverse conditions.

The impoundment on the Pemigewasset River behind Ayers Island Dam at Bristol, New Hampshire, provides an excellent example of the consequences of large quantities of suspended solids discharged to a stream. Deep sludge deposits exist in this impoundment which tend to fill the reservoir and reduce or eliminate many water uses. In addition, the dissolved oxygen is depleted near the bottom, and hydrogen sulfide is generated. When the water is released at Ayers Island Dam, the hydrogen sulfide is given off to the atmosphere, creating obnoxious odors and discoloring the paint of nearby houses.

On August 18, 1965, dozens of homes in Bristol, New Hampshire, were disfigured when hydrogen sulfide from the Pemigewasset River turned the paint on the homes an ugly dark color. The damage ran into thousands of dollars. Hydrogen sulfide again disfigured about fifty homes in Bristol, New Hampshire, on August 23, 1966.

As a result of nuisances caused by waste discharges to the Pemigewasset River, the Franconia Paper Corporation is under a court order as of March 30, 1966, which in part reads "If...the nuisance can be abated by appropriate measures short of complete prohibition of pollution...no reason appears why the employment of such measures may not

be required by appropriate order prohibiting further pollution... an unconditional order which would require immediate cessation of all pollution of the waters in question may be entered if the private nuisance can be abated in no other way." The entire court order is given in the Appendix.

Property values along the Pemigewasset River have been reduced; persons living near the river are disgusted with the pollution. Some families owning homes along the river have had to move to rented quarters elsewhere during the summer months to escape the odors. The operator of a boys' camp along the Ayers Island impoundment was compelled to construct a swimming pool at a cost of $12,000 to offer water activities during the summer. He must also bus his registrants to ponds or lakes in other areas for boating and training activities requiring body contact with the water. The enrollment dropped twenty per cent in 1965. The camp owner feels the pollution of the Pemigewasset River was a strong factor in the decline. Large sludge pads were evident in the small backwash streams at the camp.

DISSOLVED OXYGEN

Sewage and many industrial wastes contain organic matter which decomposes and exerts an oxygen demand in the receiving stream. If the dissolved oxygen (D.O.) is reduced below an adequate level, the fish population and the aquatic life on which the fish feed are killed or driven out of the area. Most water pollution control agencies have

adopted a minimum 5 mg/l D.O. objective to maintain the maximum potential warm water fish population. The New Hampshire water quality standard for Class C waters required the dissolved oxygen to be not less than 5 mg/l. Class C waters are acceptable for recreational boating, fish habitat and industrial water supply. See Table 2.

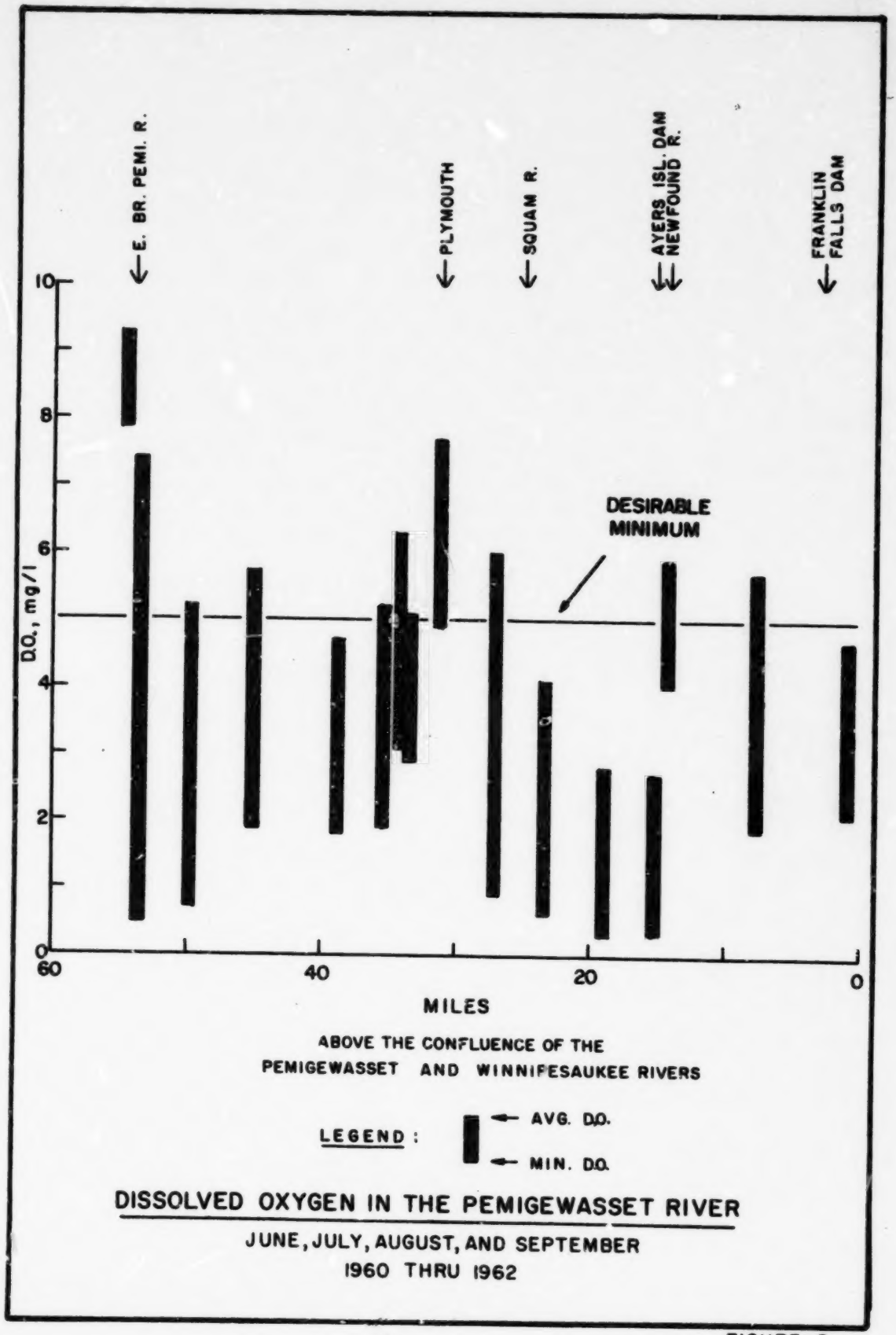
The New Hampshire Water Pollution Control Commission obtained dissolved oxygen values in the Pemigewasset River during the critical months of June through September of 1960, 1961 and 1962. Results of these tests are presented in Figure 6. Average concentrations of dissolved oxygen are considerably below that of the background station upstream of the East Branch Pemigewasset River. The section of the river behind the Ayers Island Dam showed the effects of reduced reaeration and sludge deposits. An average of 2.7 mg/l of oxygen occurred at the dam, only about half the concentration considered to be the minimum for good fish habitat. Minimum values of dissolved oxygen were below 5 mg/l at every sampling location downstream of the East Branch Pemigewasset River. Values below 1 mg/l were common. With few exceptions, the dissolved oxygen levels in the Pemigewasset River from the East Branch Pemigewasset River in Lincoln, New Hampshire, to the mouth in Franklin, a distance of fifty-four miles, are inadequate to support desirable fish life.

SULFITE WASTE LIQUOR

The degree of interstate pollution resulting from waste discharges to the Pemigewasset River was evaluated by intensive studies undertaken by the Merrimack River Project during 1965. Sulfite waste liquor analyses were carried out by the Pearl-Benson Test, on some 284 samples of the Pemigewasset and Merrimack rivers from Lincoln, New Hampshire, to Lawrence, Massachusetts, and from every significant tributary.

Results of the study indicate that, of the sulfite waste liquor found in the Merrimack River at Lawrence, Massachusetts, 96.6 per cent originate from the Franconia Paper Corporation, Lincoln, New Hampshire. The remainder is contributed by the various tributaries, with the Nashua River having 1.36 per cent of the total. The sources of the sulfite waste liquor reaching Lawrence, along with the per cent from each, are shown in Figure 7.

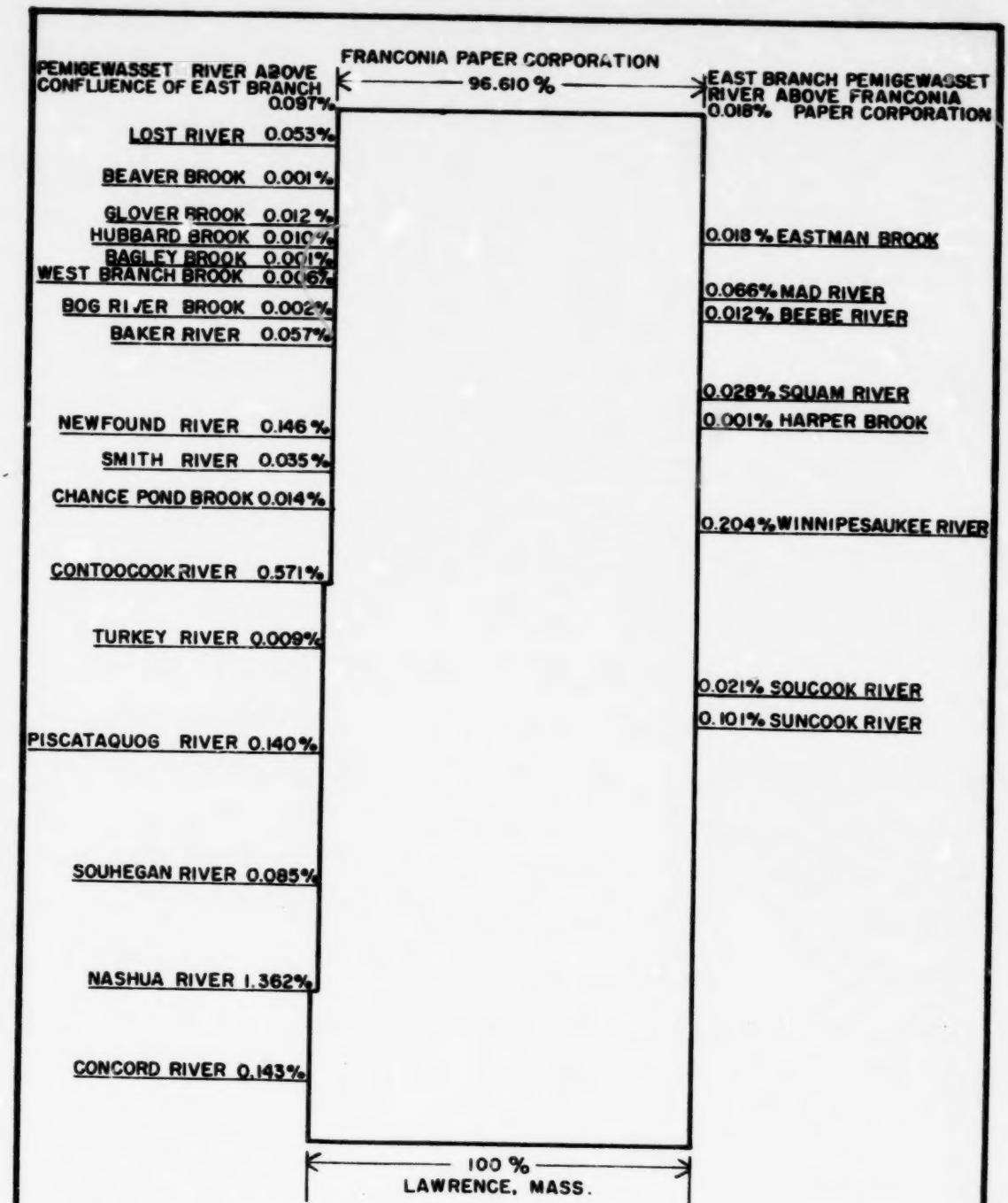
Samples were obtained every thirty minutes from the East Branch Pemigewasset River below the Franconia Paper Corporation and composited over a twenty-four hour period. Laboratory tests, using the Warburg apparatus, indicated that after fifteen days nearly all the biodegradable organic materials had been oxidized. However, the sulfite waste liquor was reduced only 6.5 per cent. This indicates that the lignin sulfonates are very stable and would be expected to persist in the receiving stream as the water flowed from Lincoln, New Hampshire, into Massachusetts.



DISSOLVED OXYGEN IN THE PEMIGEWASSET RIVER

JUNE, JULY, AUGUST, AND SEPTEMBER
1960 THRU 1962

FIGURE 6



SOURCES OF SULFITE WASTE LIQUOR (PEARL-BENSON TEST) TO PEMIGEWASSET-MERRIMACK RIVERS REACHING LAWRENCE, MASS.

FIGURE 7

Lignin-like materials other than lignin sulfonates are also detected by the Pearl-Benson test. The only source of sulfonated lignins in the Merrimack River Basin is the Franconia Paper Corporation of Lincoln, New Hampshire. The very small quantity of materials from tributaries, which give a positive reaction with the Pearl-Benson test are not sulfonated lignins.

To further substantiate that the sulfite waste liquor found in the Pemigewasset and Merrimack Rivers consists primarily of sulfonated lignins, arrangements were made with the Research and Advanced Development Division of AVCO Corporation to analyze five selected samples by means of a test which is specific for lignin sulfonates. The five samples were:

1. Sulfite waste liquor from a Franconia Paper Corporation digestor.
2. Pemigewasset River below the East Branch at North Woodstock, New Hampshire.
3. Water intake, Lowell, Massachusetts.
4. East Branch Pemigewasset River above Franconia Paper Corporation.
5. Highly colored water from a swamp in Massachusetts.

Results indicated that lignin sulfonates were contained in the first three samples and that the concentrations were directly proportional to the sulfite waste liquor concentrations found in each sample by the Pearl-Benson test. Lignin sulfonates were not detected in the two background samples, including the highly colored swamp water.

On another occasion, the Lawrence Experiment Station of the Massachusetts Department of Public Health passed approximately 8,000 gallons of water from the Merrimack River at Lawrence, Massachusetts, through ion exchange resins and recovered the materials absorbed by the resins. The Merrimack River Project obtained a portion of the concentrate for tests. The characteristics were very similar to sulfite waste liquor.

Based on the samples of the tributaries, research work of the AVCO Corporation and the water concentrate at Lawrence, it can be said that interstate pollution results from the sulfite waste liquor discharged by the Franconia Paper Corporation, Lincoln, New Hampshire.

Waters containing lignins have a dark color. If the colored waters are used as a source of municipal water or, as in many cases, industrial water supply, the materials causing the color must be removed. Public Health Service Drinking Water Standards, which are followed in Massachusetts for limits of color, state that color of drinking water must not exceed fifteen units.

Analyses of the 284 samples obtained in the Merrimack River Basin showed a linear relationship on a log-log graph between true color and sulfite waste liquor concentration. The correlation coefficient was 0.58, which is a relatively good correlation. See Figure 8. Thus, it is apparent that as the sulfite waste liquor increases in the river, the color of the river water also increases.

Tests were performed by the Merrimack River Project to relate the alum dosages required to remove different amounts of color. To

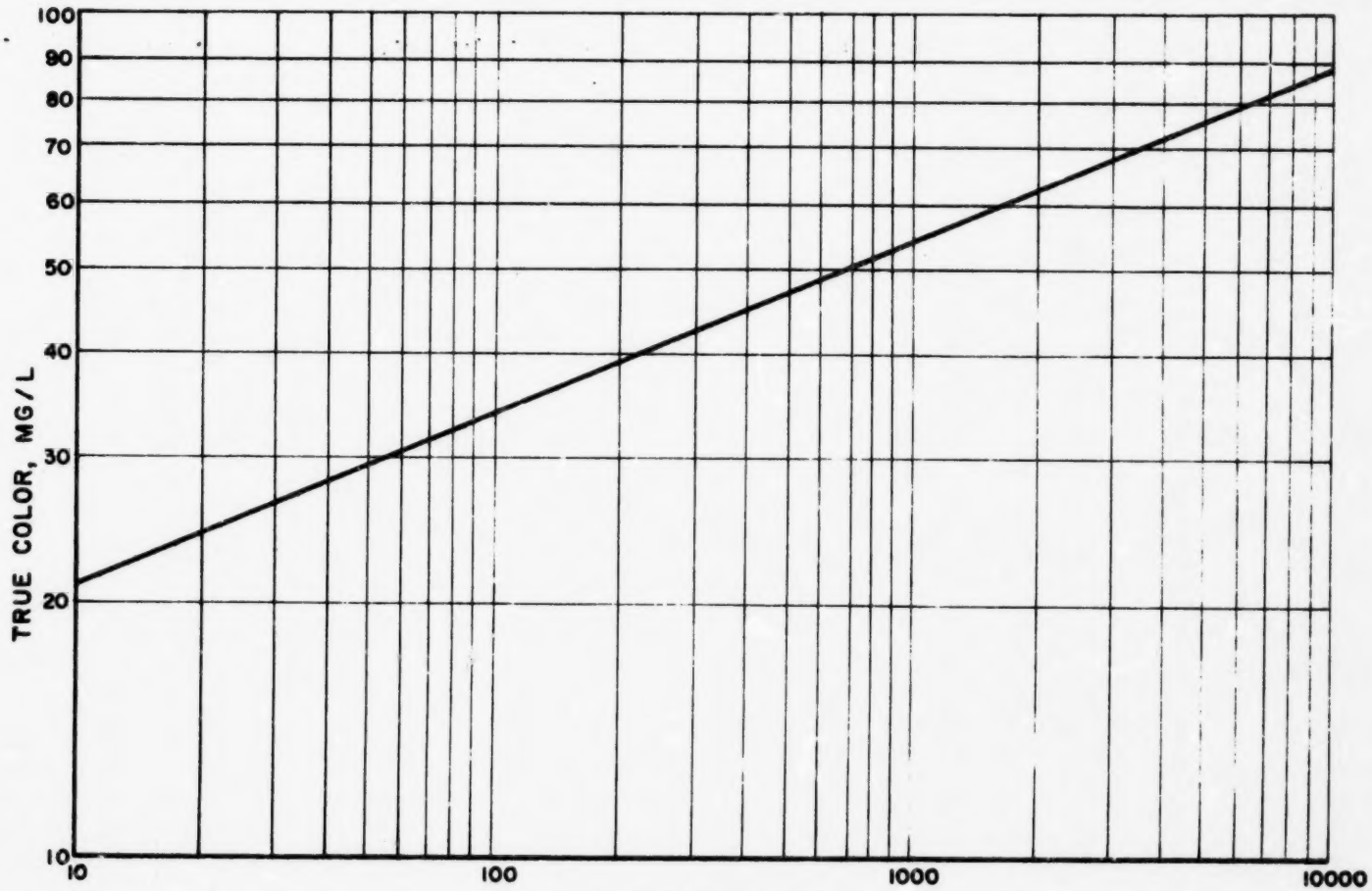


FIGURE 8

TRUE COLOR VS. SULFITE WASTE
LIQUOR AS FOUND IN MERRIMACK RIVER BASIN

obtain the different levels of color, a color reagent derived from sulfite waste liquor from Franconia Paper Corporation was added to Lawrence, Massachusetts, tap water. The results are presented in Figure 9 and show that as the color at a municipal or industrial water intake increases, the cost of chemicals to reduce the color to acceptable levels also increases. For example, 20 ppm of alum were required to reduce the color from 55 ppm to 15 ppm.

This confirms similar conclusions arrived at as a result of work carried out by the National Council for Stream Improvement (of the Pulp, Paper and Paperboard Industries) Inc. at Louisiana State University. The latter research indicated that one part of alum was required to remove each four parts of color added to the water. It was concluded that there was an increased coagulant requirement for surface waters containing color of pulping origin.

Estimates were made of the approximate extra costs that the Lowell and Lawrence, Massachusetts, water treatment plants encounter due to the wastes discharged by the Franconia Paper Corporation of Lincoln, New Hampshire. The costs of extra chemical usage for these two cities is a minimum of $8,300 per year.

In addition to increased water treatment costs for municipalities and industries, color in a stream has other deleterious effects. In a section of stream or reservoir used for recreational purposes, a swimmer or water skier who is below the water surface and is in danger of drowning could not easily be seen. Besides being esthetically displeasing, a dark colored stream results in staining of boats and reduced property values along its banks.

FUTURE WATER QUALITY

Under existing New Hampshire laws, the New Hampshire State Legislature is the organization that officially classifies state streams according to water use and quality standards. The New Hampshire Water Pollution Commission makes recommendations to the Legislature after studies of present and potential water uses and water quality.

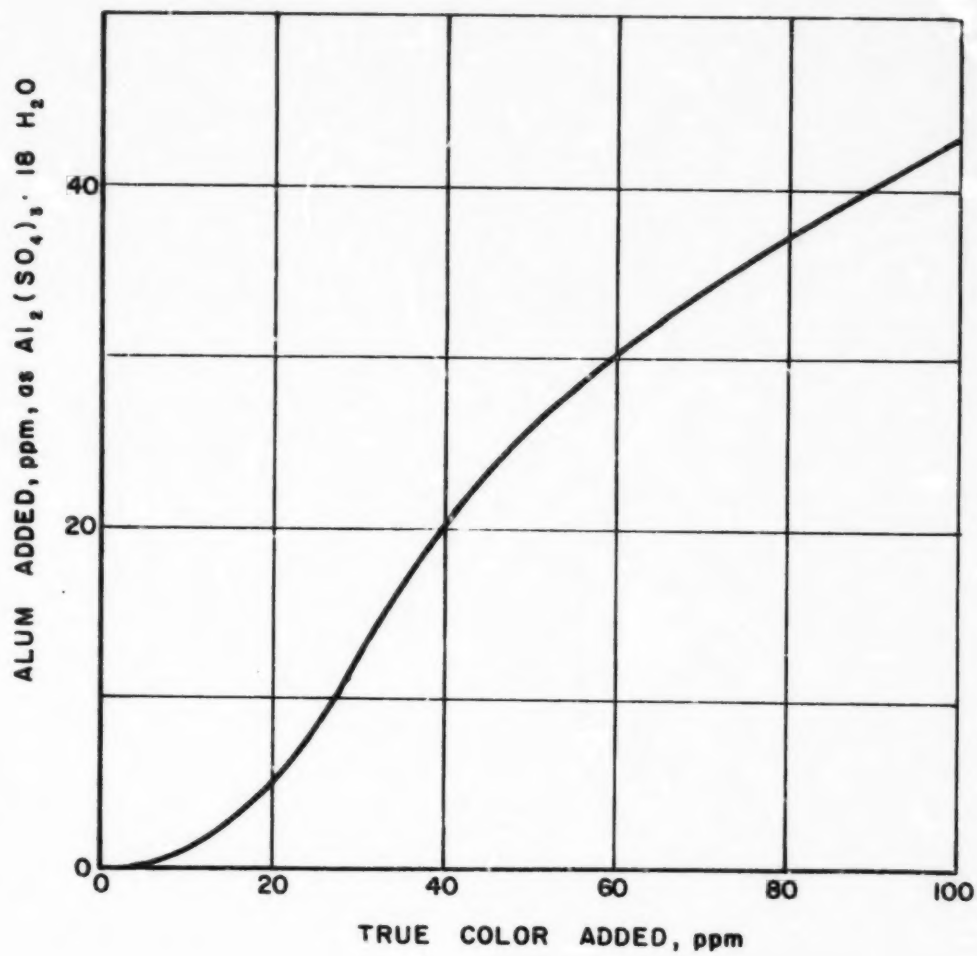
In November 1958, the New Hampshire Water Pollution Commission completed a detailed report which contained an excellent summary of the water quality conditions of the Pemigewasset River and recommendations of the Commission for classification. The recommendations were, in part:

a. The East Branch Pemigewasset River from the dam of the Franconia Paper Corporation to its confluence with the Pemigewasset River--Class C.

b. The Pemigewasset River from its confluence with the East Branch to the steel highway bridge crossing about 0.6 miles below the village of North Woodstock--Class C.

c. The Pemigewasset River from the steel highway bridge below North Woodstock to Eastman's Falls Dam in Franklin--Class B-1.

d. Squam River, a Pemigewasset River tributary--Class B-1.



MINIMUM ALUM REQUIRED TO
REDUCE COLOR TO 15 PPM OR LESS

FIGURE 9

e. Newfound River, a Pemigewasset River tributary, downstream of Route 3A bridge--Class B-1.

f. Baker River, in the Town of Plymouth, from a point 300 feet upstream of the bridge abutment of the Plymouth to Woodsville branch of the Boston and Maine Railroad to confluence with the Pemigewasset River--Class B-1.

However, the New Hampshire Legislature did not follow the recommendations of the New Hampshire Water Pollution Control Commission and classified each of the above sections of stream Class D. As may be seen in Table 2, Class D streams are devoted to transportation of sewage or industrial waste without nuisance. They are not acceptable for fishing, boating, swimming or municipal or industrial water supplies, even with water treatment. A ten year compliance period was permitted.

As a result, a prime recreational stream, such as the Pemigewasset River, is placed in a status in which it is only devoted to transportation of sewage or industrial waste without nuisance. This is especially true since means are presently available to correct the pollution problem. Waste discharges should, therefore, be controlled to allow economic growth of the area and recreational use of the river. An adequate pollution abatement program would permit full use of the stream.

Water uses which should be protected in the East Branch Pemigewasset River below the Franconia Paper Corporation dam; the Pemigewasset River from the confluence with the East Branch to its

confluence with Hubbard Brook; and the Squam River from the outlet of Little Squam Lake to the confluence with the Pemigewasset River, include:

Industrial Water - Process and Cooling

Recreation - Limited Body Contact

Fish and Wildlife

Irrigation

Esthetics

Water uses which should be protected in the Pemigewasset River from the confluence with Hubbard Brook in Thornton, New Hampshire, to its mouth in Franklin; Baker River in the town of Plymouth, from a point 300 feet upstream of the bridge abutment of the Plymouth to Woodsville branch of the Boston and Maine Railroad to confluence with the Pemigewasset River; and Newfound River in the town of Bristol from the Highway bridge on Route 3A (Lake Street) between Chandler and Cresent Streets to the confluence with the Pemigewasset River include:

Municipal Water

Industrial Water - Process and Cooling

Recreation - Whole Body Contact

Recreation - Limited Body Contact

Fish and Wildlife

Irrigation

Esthetics

If the recommendations of this report (Part I - Summary, Conclusions and Recommendations) are followed, water quality of sufficient purity to accommodate the various water uses will be attained.

SUMMARY AND CONCLUSIONS

In accordance with the written request to the Secretary of Health, Education, and Welfare from the former Governor Endicott Peabody of Massachusetts, dated February 12, 1963, and on the basis of reports, surveys, or studies, the Secretary of Health, Education, and Welfare, on September 23, 1963, called a conference under the provisions of the Federal Water Pollution Control Act, as amended (33 USC 466 et seq.), in the matter of pollution of the interstate waters of the Merrimack and Nashua Rivers and their tributaries (Massachusetts-New Hampshire) and the intrastate portions of those waters within the state of Massachusetts. Interstate pollution originating in the Pemigewasset River Basin was included in this conference. The conference was held February 11, 1964, in Faneuil Hall, Boston, Massachusetts.

Serious pollution exists in the Pemigewasset River from the confluence with the East Branch Pemigewasset River in Lincoln, New Hampshire, to the confluence of the Winnipesaukee River in Franklin, New Hampshire, due to the discharge of sewage and industrial wastes in the Basin. Effects of these discharges persist all the way into Massachusetts.

Discharges of raw sewage from several towns result in excessive densities of bacteria and make much of the Pemigewasset River unsuitable for recreational purposes, even where only limited

body contact is involved. About twenty-nine of the thirty-five miles of stream between North Woodstock and New Hampton are above the 5,000 coliforms per 100 ml limit usually recommended for recreational use. Some of these bacteria may be pathogens which can infect persons ingesting the water.

Suspended solids discharged to the Pemigewasset River watershed are equivalent to those in the raw sewage of 287,500 persons, of which over 98 per cent emanate from industrial plants. These solids result in sludge deposits, especially in the impoundment behind Ayers Island Dam. The sludge reduces or eliminates aquatic life which serves as food for fishes, depletes the stream oxygen supply, and produces offensive odors. Hydrogen sulfide, resulting from sludge deposits behind Ayers Island Dam, caused thousands of dollars of damage to houses in Bristol, New Hampshire, on August 18, 1965, and on August 23, 1966, by discoloring the paint on the houses.

Dissolved oxygen concentrations in the Pemigewasset River are depressed by the discharge of organic materials which decompose in the river and exert an oxygen demand. Minimum dissolved oxygen concentrations were below desirable levels from the East Branch Pemigewasset River in Lincoln, New Hampshire, to the mouth of the Pemigewasset in Franklin. The Franconia Paper Corporation is responsible for 94.5 per cent of the oxygen demand in the Pemigewasset River Basin, with a discharge having an oxygen demand equivalent to that of the raw sewage of 400,000 persons. Low dissolved oxygen concentrations destroy fish, fish food organisms and other desirable aquatic life.

Sulfite waste liquor, released to the Pemigewasset River by the Franconia Paper Corporation, not only creates an enormous oxygen demand due primarily to the wood sugars, but also contains lignin sulfonates which persist as the waters flow into Massachusetts. Pollution from the Franconia Paper Corporation was included in the first session of the conference. As a result of the sulfite waste liquor, the river is discolored, adding to the water treatment costs at Lowell and Lawrence, Massachusetts.

The Pemigewasset River is in the heart of prime recreational area of New Hampshire. However, as a result of pollution, recreational use of the Pemigewasset is reduced or destroyed, impeding the economic growth of the area downstream of the pollutional discharges.

Water quality requirements have been developed for various sections of the Pemigewasset River Basin. When these requirements are met, additional use could be made of the waters of the area. Water uses that would be permitted in the East Branch Pemigewasset River below the Franconia Paper Corporation dam; the Pemigewasset River from the confluence with the East Branch to its confluence with Hubbard Brook; and the Squam River from the outlet of Little Squam Lake to the confluence with the Pemigewasset River include:

Industrial Water - Process and Cooling

Recreation - Limited Body Contact

Fish and Wildlife

Irrigation

Esthetics

Water uses that would be permitted in the Pemigewasset River from the confluence with Hubbard Brook in Thornton, New Hampshire, to its mouth in Franklin; Baker River in the town of Plymouth, from a point 300 feet upstream of the bridge abutment of the Plymouth to Woodsville branch of the Boston and Maine Railroad to confluence with the Pemigewasset River; and Newfound River in the town of Bristol from the Highway bridge on Route 3A (Lake Street) between Chandler and Cresent Streets to the confluence with the Pemigewasset River include:

Municipal Water

Industrial Water - Process and Cooling

Recreation - Whole Body Contact

Recreation - Limited Body Contact

Fish and Wildlife

Irrigation

Esthetics

Sulfite waste liquor continues to be discharged to the East Branch Pemigewasset River by the Franconia Paper Corporation, Lincoln, New Hampshire, causing pollution which endangers the health or welfare of persons in Massachusetts and, therefore, is subject to abatement under the provisions of the Federal Water Pollution Control Act (33 USC 466 et seq.).

If the recommendations of this report (Part I - Summary, Conclusions and Recommendations) are followed, water quality of sufficient purity to accommodate the various water uses will be attained.

APPENDIX

Belknap,
No. 5436

H. THOMAS URIE & a. v. FRANCONIA PAPER CORPORATION.

Argued January 5, 1966.
Decided March 30, 1966.

Upton, Sanders & Upton (Mr. Richard F. Upton orally), for the plaintiffs.

Orr & Reno (Mr. Robert H. Reno orally), for the defendant.

WHEELER, J. This action is a bill in equity brought by H. Thomas Urie and fifteen others seeking to enjoin and restrain the defendant from further pollution of the waters of the Pemigewasset River and that defendant be ordered to take such reasonable measures as may be required to abate the private nuisance resulting to the plaintiffs.

It is alleged in the petition that the plaintiffs are owners of real estate situated in the Bristol-New Hampton area in the valley of the Pemigewasset River. Certain of the plaintiffs are riparian owners of real estate bordering said Pemigewasset River. The defendant, Franconia Paper Corporation is engaged in the manufacture of pulp and paper products at Lincoln on or near the Pemigewasset River upstream from the lands of the plaintiffs.

It is further alleged that the defendant in the course of its manufacturing processes is and for several years has been discharging sulfite waste liquors, wood and pulp waste material and other pollution into the waters of said river, that the intensity and volume of such discharge has been increasing in the last three or four years and that the waste and pollution is and has been flowing downstream in said river through and past the land of the plaintiffs during this period.

Further, the petition alleges that in times of warm weather or low water conditions in the river the said wastes, solids and pollution by the time they have made their way downstream to a point near the lands of the plaintiffs, have worked, fermented or decayed to the point that they have become foul and offensive to human beings and there has thereby resulted the deposit of foul and offensive sludge and decayed matter in substantial quantities on the lands of those plaintiffs who are riparian owners. It is further alleged that during such warm weather periods the pollution of the waters by the defendant has caused the discharge of vile, obnoxious and offensive odors which have permeated the atmosphere on and near the lands and premises of the plaintiffs causing substantial and appreciable injury to the plaintiffs in their use and enjoyment of their property and rendering their enjoyment of their property uncomfortable and inconvenient.

The plaintiffs assert that the action of the defendant in the circumstances alleged is an unreasonable use of its premises and of the waters of the said Pemigewasset River and constitutes a private nuisance as to these plaintiffs and that such pollution by the defendant in the circumstances alleged is a constantly recurring grievance, day by day.

d

In their brief the plaintiffs advise that since the instant action was instituted there has been determined and they will offer to prove that the odors discharged from the polluted river waters are hydrogen sulfide gas which is not only highly offensive to human beings but also attacks the lead-based paint on dwellings and other buildings in the vicinity causing them to turn black, and that the existence of this condition has also caused a substantial depreciation in property values of the plaintiffs which plaintiffs stand ready to prove.

The defendant in its answer makes a general denial of the allegation that its operations are polluting the Pemigewasset River and by way of affirmative defense alleges that the East Branch of the Pemigewasset River, in the towns of Lincoln and Woodstock, from the dam of the Franconia Paper Corporation to the confluence with the Pemigewasset River has been classified by the Legislature as Class D water and that the Pemigewasset River from its confluence with the East Branch of the Pemigewasset River in the town of Woodstock to the crest of the Eastman Falls Dam in Franklin has been classified by the Legislature as Class D water. Laws of 1959, 243:1, VII, VIII. See note following RSA 149:6.

The defendant further alleges that no order for abatement of pollution of the waters of the East Branch of the Pemigewasset River from the dam of the Franconia Paper Corporation to the confluence with the Pemigewasset River and of the Pemigewasset River from its confluence with the East Branch of the Pemigewasset River to the crest of the Eastman Falls Dam in Franklin may be entered prior to September 1, 1969. Laws of 1959, 243:2. Defendant's answer further alleges that if the waters of the Pemigewasset River are polluted as alleged by the plaintiffs such pollution has been caused by persons and municipalities other than by the defendant.

The plaintiffs demurred to the affirmative defense pleaded in the defendant's answer on the grounds that said defense as pleaded is not sufficient in law.

All questions of law raised by the plaintiffs' demurrer were reserved and transferred in advance of trial by Griffith, J.

The plaintiffs seek relief from a private nuisance, as landowners, and not as members of the public, specially damaged by a public nuisance. Cf. St. Regis Paper Co. v. Board, 92 N. H. 164. A nuisance may simultaneously be a public and private nuisance. McKinney v. Riley, 105 N. H. 249, 254; White v. Suncook Mills, 91 N. H. 92, 97. See also discussion in Restatement, Torts, pp. 217, 218.

It has been held by the weight of authority that what is authorized by law cannot be a public nuisance, but such authorization does not affect any claim of a private citizen for damages for injury "caused by the authorized act not experienced by the public at large, or for an injunction." 39 Am. Jur., Nuisances, p. 481, ss. 204, 205. See also Commerce Oil Refining Corp. v. Miner, 281 F. 2d 465 (1st Cir.).

d

As the plaintiffs point out, there is nothing in RSA ch. 149 to indicate a legislative intent to take away any private rights of individual landowners to seek redress in equity to prevent pollution of the river. It seems doubtful if the Legislature has constitutional power to permit the defendant to continue to commit private nuisances until September 1, 1969, since such legislation would constitute taking private property for a non-public purpose. Eaton v. Railroad, 51 N. H. 504, 510; Thompson v. Company, 58 N. H. 108.

RSA ch. 149 is essentially an act to prohibit the pollution of public waters in the interest of protecting the public health and welfare. State v. Goffstown, 100 N. H. 131, 134; Shirley v. Commission, 100 N. H. 294, 299, 300. It was not intended to abrogate or suspend protection of the rights of individual landowners to be free from private nuisance.

The Class D classification is the "lowest classification" established by the statute, but even it is intended to permit "transportation of sewage or industrial wastes, or both, without nuisance." RSA 149:3 IV, supra. The provisions of Laws 1959, 243:2 allow a period of ten years within which to abate pollution which lowers the quality of the water below the Class D requirements. However, the language defining the classification as one which shall permit use "without nuisance" was not intended to sanction the continuance of a private nuisance in the meantime, or to suspend injunctive relief calculated to cause abatement of such a nuisance.

If, as the plaintiffs assert, the nuisance can be abated by appropriate measures short of the complete prohibition of pollution which the first prayer of their bill seems to seek, no reason appears why the employment of such measures may not be required by appropriate order prohibiting further pollution unless such measures are employed within a reasonable time. See Annot. 46 A.L.R. 8, 35, par. V. On the other hand, an unconditional order which would require immediate cessation of all pollution of the waters in question may be entered if the private nuisance can be abated in no other way.

The allegations in the plaintiffs' petition state a cause of action for equitable relief.

The order is

Plaintiffs' demurrer sustained; remanded.

All concurred.

d

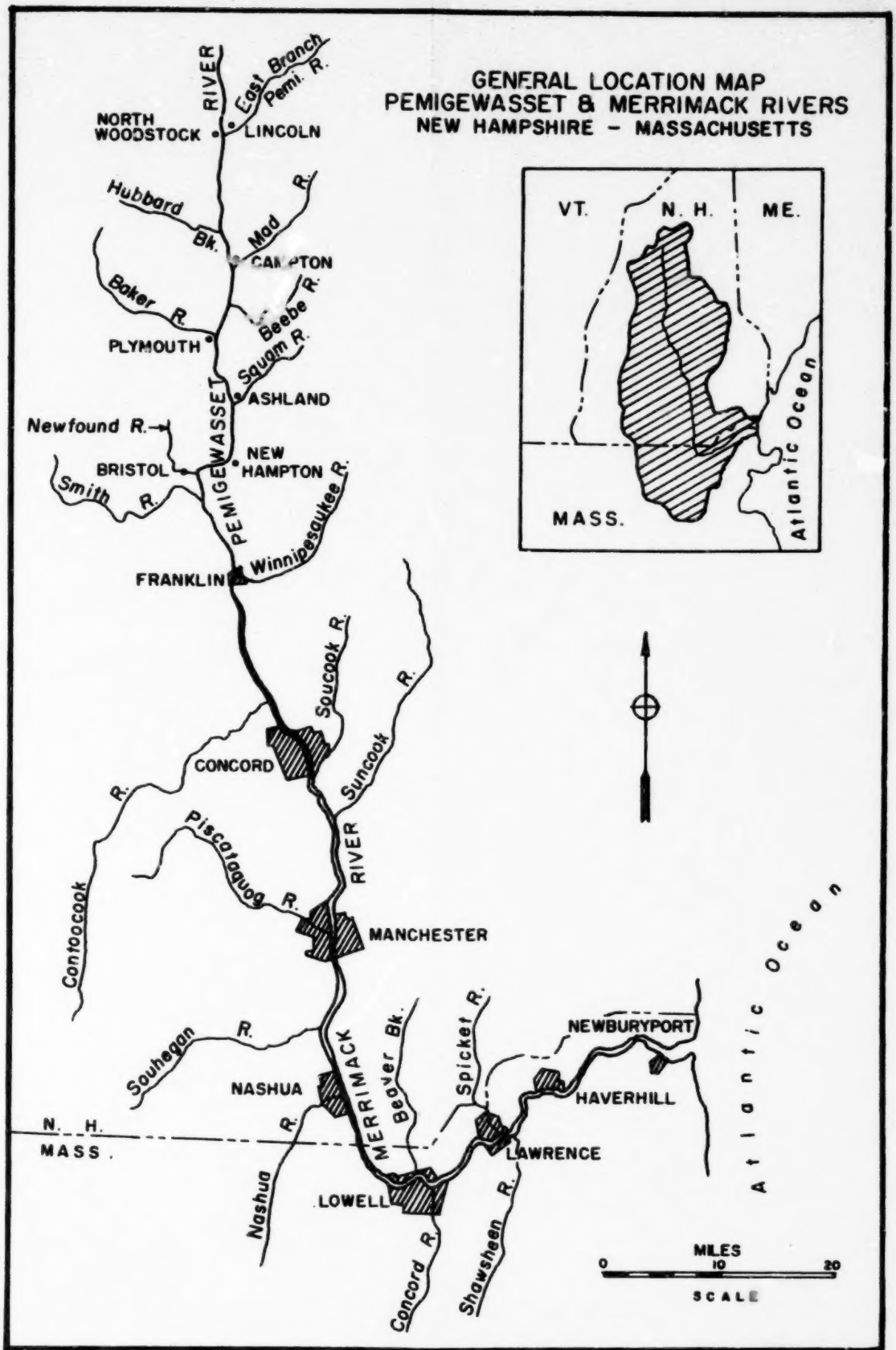

GENERAL LOCATION MAP
PEMIGEWASSET & MERRIMACK RIVERS
NEW HAMPSHIRE - MASSACHUSETTS
VT.
N. H.
ME.
MASS.
Atlantic Ocean
East Branch Pemi. R.
PEMIGEWASSET RIVER
NORTH WOODSTOCK
LINCOLN
Hubbard Bk.
Mad R.
CAMPTON
Baker R.
Beebe R.
PLYMOUTH
Squam R.
ASHLAND
Newfound R.
BRISTOL
NEW HAMPTON
Smith R.
Winnipesaukee R.
FRANKLIN
Soucook R.
Suncook R.
CONCORD
Contoocook R.
Piscataquog R.
MERRIMACK RIVER
MANCHESTER
Souhegan R.
NASHUA
Beaver Bk.
Spicket R.
NEWBURYPORT
HAVERHILL
N. H.
MASS.
Nashua R.
LAWRENCE
LOWELL
Concord R.
Shawsheen R.
Atlantic Ocean
MILES
0
10
20
SCALE

FIGURE 1